COMMENT: doi: 10.1130/G24099C.1

Peter B. Kelemen*
Lamont-Doherty Earth Observatory, Columbia University,
Palisades, New York 10964, USA

Gene Yogodzinski
Department of Geological Sciences, University of South Carolina,
Columbia, South Carolina 29208, USA

Streck et al. (2007) state that primitive andesite lavas (Mg# > 0.6; 53–63 wt% SiO₂) from Mt. Shasta are not primary melts, but instead are mixtures of evolved, high-Sr/Y, low-Mg# dacite with primary, low-Sr/Y, high-Mg# basalt. They propose that this mixing forms primitive andesites worldwide, and they dismiss the idea that primitive andesite is an end member in arc magmatism.

Magma mixing is evident in primitive Aleutian andesites (e.g., Kay, 1978; Kelemen et al., 2003a; Yogodzinski and Kelemen, 1998) and xenoliths (e.g., Conrad et al., 1983; Yogodzinski and Kelemen, 2007). Streck et al. imply that our data support their hypotheses, but Aleutian mixing requires a primitive andesite end member with the highest Mg#, Cr, Ni, Th, Ba, Sr and light rare Earth elements (REE), and lowest Y and heavy REE. We show this with Sr/Y versus Mg# (Fig. 1A). High-Sr/Y lavas are mixtures of a low-Mg#, low-Sr/Y component and a high Sr/Y, high Mg# component. The high Sr/Y component is an andesite (Fig. 1B) with Mg# ~0.7, in Fe/Mg equilibrium with mantle olivine. There are no low Mg# lavas with higher Sr/Y, so the Streck et al. process did not form end-member Aleutian primitive andesites.

Mt. Shasta data (Fig. 2) are similar to that from the Aleutians, with a mixing trend extending toward a high-Sr/Y, high-Mg# andesite end member, nearly perpendicular to the mixing proposed by Streck et al. If their process formed any lavas at Mt. Shasta, they are rare. In any case, by analogy with the Aleutians, their dacite end member (Mg# 0.61) formed from a primitive andesite.

Streck et al. also misrepresent Pb isotope data for arc lavas. Citing our work (Kelemen et al., 2003b), Streck et al. (2007, p. 353) write, “elevated Pb isotopic signatures of [primitive andesites] worldwide could be interpreted in terms of a crustal contribution.” However, Kelemen et al. (2003b, our Figure 9; 2003a, our Figures 7–11) show that Aleutian primitive andesites have the most depleted, least “crustal” Sr, Nd, and Pb isotopes of any arc magmas worldwide.

REFERENCES CITED


© 2007 Geological Society of America. For permission to copy, contact Copyright Permissions, GSA, or editing@geosociety.org.

Figure 1: Compositions of lavas from the oceanic Aleutian arc (compiled by Kelemen et al. [2003a], plus lavas dredged on the 2005 Western Aleutian Volcano Expedition). Yb*9.8 used instead of Y for samples with Sr data but no Y. One sample with discrepant Y and Yb is omitted.

Figure 2: Compositions of lavas from Mt. Shasta (Grove et al., 2002, 2005). Right panel, with expanded vertical axis, illustrates lava data and mixing trajectories from Streck et al. (2007). Along these mixing trajectories, symbols are as follows: Circle—“dacite;” square—“high alumina olivine tholeiite” (HAT); diamond—“basaltic andesite” (BA); filled symbols—lava mixing alone; open symbols—lava mixing after harzburgite is added to mafic end member in proportions required by Streck et al.
versus plagioclase in the crust would control melt compositions. In any
might play little part, but rather the amount of garnet (and/or amphibole)
Yogodzinski, G.M., and Kelemen, P.B., 1998, Slab melting in the Aleutians:
implications of an ion probe study of clinopyroxene in primitive adakite and
S0012-821X(98)00041-7.
from Aleutian xenoliths: Implications for primitive subduction magmatism

REPLY: doi: 10.1130/G24356Y.1

Martin J. Streck
Department of Geology, Portland State University,
Portland, Oregon 97207, USA
William P. Leeman
National Science Foundation, Division of Earth Science,
Arlington, Virginia 22230, USA
John T. Chesley
Department of Geosciences, University of Arizona,
Tucson, Arizona 85721, USA

The comment by Kelemen and Yogodzinski (2007) criticizes
extrapolation of our results for Mt. Shasta high-Mg andesite (S-HMA)
to interpretations of other occurrences of HMA. Our intent was to en-
courage the petrologic community to re-examine all HMA to better
understand their petrogenesis on an individual basis. Where mixing is
evident, it is critical to identify the end members involved and their ori-
gins. Although we did not specifically link our study to Aleutian HMAs
(A-HMA), Kelemen and Yogodzinski suggest the latter could be a common
high-Mg# and high-Sr/Y end member with global significance to arc
petrology, including Mt. Shasta.

S-HMA can be explained as a mixture of high-Sr/Y dacite and low-
Sr/Y basalt, with ultramafic contaminants (Streck et al., 2007). S-HMA
differs from A-HMA in having significantly higher MgO, Ni, Cr, etc. (Fig. 1).
However, the presence of reversely zoned clinopyroxene with Fe-rich
cores (Mg# ≤75) in some of the highest-Sr/Y A-HMAs (Yogodzinski and
Kelemen, 1998; Kelemen and Yogodzinski, 2007), indicate that these lavas
may also be mixtures of low- and high-Mg# magmas. We do accept that
they are unique, but we question their role as being globally significant and
that they contribute to formation of magmas at Mt. Shasta (Figs. 1 and 2).

Although Mt. Shasta dacites with narrow ranges in SiO2 (62–64 wt%)
and MgO (3–4 wt%) appear to project toward A-HMA (Kelemen and
Yogodzinski, 2007, their Fig. 2) (our Fig. 1A), in diagrams such as Sr
versus Ba and Sr/Y versus La (Fig. 2), the field for A-HMA lies well off
the Shasta dacite trend (as well as opposite the dacite trend from S-HMA)
and appears to be a poor end member. It is conceivable that the Mt. Shasta
dacite trend (with a large range in Sr/Y) may be an artifact of generating
dacites via fractional crystallization and/or of partial melting of variable
protoliths at variable pressure. It is also possible that source Sr/Y could
vary in response to the addition of variable amounts of high-Sr/Y slab-
derived fluid. However, if the dacites are crustal melts, then slab fluids
might play little part, but rather the amount of garnet (and/or amphibole)
versus plagioclase in the crust would control melt compositions. In any
case, A-HMA is unusual in having low MgO but high Mg#: this implies
low Fe2+:Fe3+ content—could this be a consequence of oxidation of iron? Shasta
dacites similarly have high Mg#:—coincidence, or is there a connection?

Finally, our comment regarding Pb isotope data was paraphrased from
Kelemen et al. (2003, p. 616) who state: “In all of these localities [referring
to other HMA localities], other than the Aleutians, most high Mg# andesites
have elevated 206Pb/204Pb, compared to MORB. Thus lead isotope data sug-
gest the presence of a component derived either from recycling of lead from
subducted sediment, or from crustal interactions of primitive basalts with
older, continental crust and continually derived sediment.”

REFERENCES CITED

from the Mt. Shasta region, N California: Products of varying melt fraction
and water content Contributions to Mineralogy and Petrology, v. 118, p.
Grove, T.L., Parmar, S.W., Bowring, S.A., Price, R.C., and Baker, M.B., 2002,
The role of H2O-rich fluid component in the generation of primitive
basaltic andesites and andesites from the Mt. Shasta region, N California:
Contributions to Mineralogy and Petrology, v. 142, p. 375–396.
Grove, T.L., Baker, M.B., Price, R.C., Parmar, S.W., Elkins-Tanton, L.T.,
Chatterjee, N., and Müntener, O., 2005, Magnesian andesite and dacite lavas
from Mt. Shasta, northern California: Products of fractional crystallization
of H2O-rich mantle melts: Contributions to Mineralogy and Petrology,
Kelemen, P.B., and Yogodzinski, 2007, High-magnesian andesite from Mount
Shasta: A product of contamination, not primitive melt: Comment: Geology,
Kelemen, P.B., Hanbo, K., and Greene, A.R., 2003, One view of the
geochemistry of subduction-related magmatic arcs, with an emphasis on
primitive andesite and lower crust, in Rudnick, R.L., ed., The Crust,
Vol. 3, Treatise on Geochemistry (Holland, H.D., and Turekian, K.K., eds.):
from Mount Shasta: A product of magma mixing and contamination,
G23286A.1.
Yogodzinski, G.M., and Kelemen, P.B., 1998, Slab melting in the Aleutians:
Implications of an ion probe study of clinopyroxene in primitive adakite and
S0012-821X(98)00041-7.
1995, Magnesian andesite in the western Aleutian Komandorsky region:
Implications for slab melting and processes in the mantle wedge: Geologic

Figure 1. Mt. Shasta data (Baker et al., 1994; Grove et al., 2002; and this study) compared to Aleutian high-magnesian
andesite (A-HMA) of Yogodzinski et al. (1995). Circle with solid line encloses primitive A-HMA mixing end member proposed by Kelemen and

Figure 2. Mt. Shasta lavas compared to Aleutian high-magnesian
andesite (A-HMA) (data sources and legend as in Fig. 1 and Grove et al. [2002]). Double-headed arrow defines trend in Mt. Shasta
dacites (62–64 wt% SiO2).